TARGET BOX FRONT END FOR THE 30" BUBBLE CHAMBER HADRON BEAMS

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I. SCOPE AND GROUND RULES

The neutrino laboratory target box in addition to having a neutrino capability is to provide a proton beam onto the hadron target in Enclosure 100 so that secondary beams consistent with those described in the April 6, 1971 "Dear Bubbler" letter of E. Goldwasser can be constructed. The required properties of the proton beam on the hadron beam target are:

A. Intensity - about 10^8 protons per pulse

B. Pulse width - about 0.1 msec

C. Energy - up to 500 GeV/c

D. Momentum resolution - same as the EPB

E. Multiple pulse operation - have the capability of eventually giving about 5 pulses per 1 sec flat top.

The above beam is to be produced consistent with the requirements that it:

A. Introduce a minimum interface with the neutrino beam target box load

B. Not build up an excessive radiation level in Enclosure 100

C. Not require a high power beam dump at the end of the decay tunnel

II. GENERAL SOLUTION

The general approach followed in this solution is illustrated on Fig. 1. To minimize the interference with the front end of the narrow band neutrino beam, the proton beam is deflected by magnet M1 before the target box to magnet M2 which completes the nondispersive bend. In this solution it is assumed that the neutrino beam line bends are in the vertical plane and that the west side of the target box (the hadron beam side) is unused by the neutrino front end. Magnet M2 located on the hadron beam side of the target box bends the proton beam parallel to and about 14.5" from the neutrino decay pipe axis so that it is aligned with the 4" hadron hole in the beam dump in Enclosure 100.

Magnet M2 can be a D-C operated magnet. The status of magnet M1 specifies the operation of the neutrino area. With M1 powered all of the protons are directed via M2 to the hadron target. When M1 is not powered the protons continue on to the neutrino target. A simultaneous splitting of the proton beam between the two beam lines could be achieved if M1 were a pulsed septum magnet but this will not herein be considered further.

Two basic modes of operation of M1 are possible: (1) an Alternate Cycle Pulsed Mode, i.e., where M1 is activated for some machine cycles and not activated for other machine cycles, and (2) an Intra-Cycle Pulsed Mode, i.e., where M1 can be pulsed on for a small fraction of each machine cycle. The basic difference between these two methods of operation is whether M1 can be activated slowly (~ 1 sec) or rapidly (~ 0.1 msec). Table I illustrates the options of operation available within the two basic modes of operation. In the Alternate Cycle Pulsed Mode the usefulness of the hadron-proton beam with M1 on depends critically on the proton pulse profile delivered by the EPB. Mode 1.b passes too many protons to the hadron target and excessively activates Enclosure 100. To get the proper 30" bubble chamber pulse, somewhere there must be a fast kicking magnet. Modes 1.c, 1.d and 1.e all require fast kicking magnets somewhere in the beam line - in the MR extraction, in the EPB or after the hadron target. Mode 2 uses M1 as the fast kicking magnet hence not requiring it elsewhere in the "beam lines". Modes 1.e and 2 allow multiple pulsing of the hadron beam.

III. PRELIMINARY SOLUTION

To better illustrate the general solution consider the following. For a long beam spill (greater than 10 turn extraction) the EPB emittance will be approximately 0.09 π mm-mrad in the vertical plane and 0.03 π mm-mrad in the horizontal plane. If the EPB is waisted to about 4 mm ϕ at the neutrino beam target and if M1 and M2 are activated, then the proton beam size at the beam dump in Enclosure 100 will be 1.2" vertical and 0.4" horizontal, thereby passing through the 4" diameter hadron hole in the beam dump without the need of quadrupole focussing.

The neutrino beam front end is assumed to be as described in the B. Barish note of October 13, 1970 and illustrated on Fig. 2. It is observed that the first quadrupole Q1 in the neutrino beam is about 68' from the upstream end of the target box. Q1 "is" a main ring 7' quad which if placed on its side (assume the neutrino front end bends in the vertical plane) is 8 3/8" thick from the center to outside edge in the midplane. A proton beam layout which misses Q1 and allows M2 to fit on the target box bed-plate (it overhangs somewhat but fits in the target tube) is given on Fig. 2 and has the following properties:

M1: located 50' upstream of the target box and on centerline; bend angle $\Delta\theta$ = 6.5 mrad
BL for 500 GeV is about 108 kG-m

M2: located 133' inside target box displaced 14.5" from centerline; bend angle $\Delta\theta$ = 6.5 mrad

The M2 magnet could be a main ring B1 magnet operating at 17.8 kG. This is what is shown on Fig. 2. In the alternate cycle pulsed mode the M1 magnet could also be a main ring B1 magnet operating at 17.8 kG. For the intracycle pulsed mode the M1 magnet could, for example, be copies of the 1963 CERN neutrino beam transport magnet (see CERN Yellow Report 64-35 by B. Langeseth) which have the following properties:

CERN 1 m Pulsed Magnet

$\int B \cdot dl$	27 kG-m
Aperture	40 mm x 66 mm H
Power	10 KW
Discharge half cycle	~ 4 msec
Water Flow	5 l/m
Rep. Rate	1/sec
Length	1.21 m
Height	0.43 m
Width	0.25 m

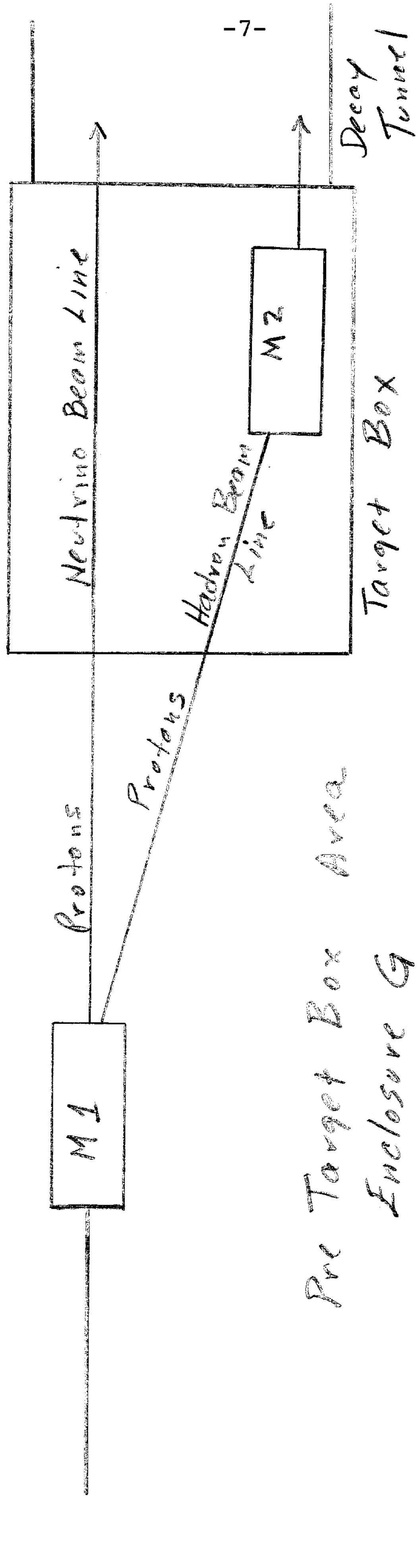
Four of these magnets would be needed for 500 GeV operation of the hadron beam. The neutrino horn pulsed power supply, presently under design, could also be used to power these magnets.

TABLE I

Operating Modes for Neutrino Area (500 GeV Protons)

Mode		Proton Pulse from EPB	M1 Status	Proton Beam Purpose	Comments
1. Alternate Cycle Pulsed Mode (M1-D.C)	a.	10^{12}/1 sec	Off	Neutrino (ν)	Normal ν beam operation
	b.	10^{12}/1 sec	On	Hadron (H)	TROUBLE - Excessive radio-activity build up in Enclosure 100
	c.	10^{10}/10 msec	On	H or Beam Testing	Single pulse B.C. operation but needs kicker magnet to shorten spill
	d.	10^{8}/0.1 msec	On	H	Single Pulse operation
	e.	> 200 msec n x 10^{8}/0.1 msec	On	H	Multiple pulse operation
2. Intracycle Pulsed Mode (M1-Pulsed)		10^{12}/1 sec	Off	ν	99.99% of beam .
			On	H	0.01% of beam could be multiple pulsed.

TM-312
2250.000



Schematic Layout of 30" Hadron Front End

Fig. 1

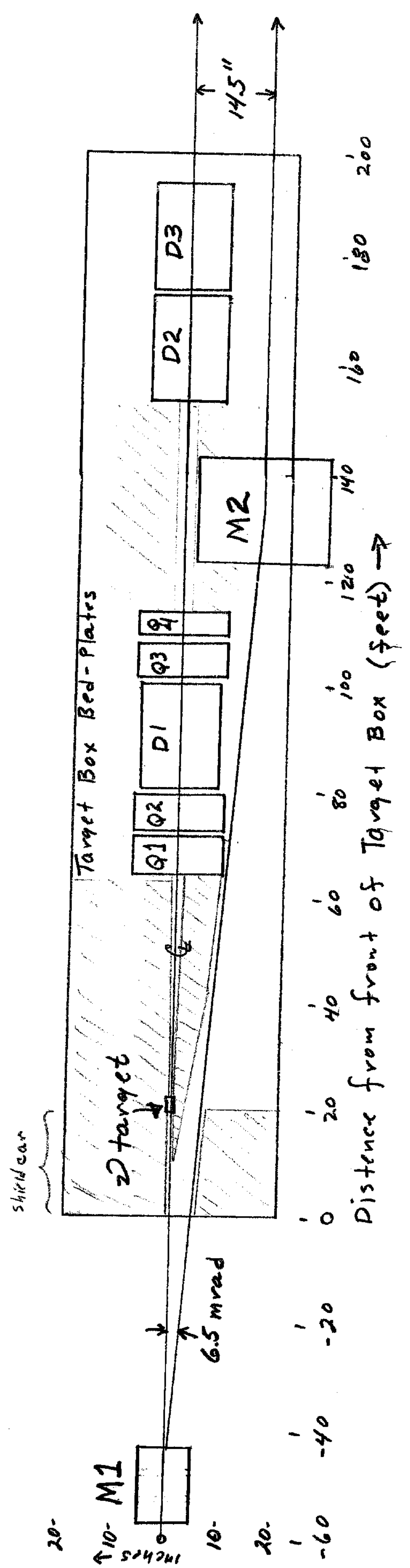


Fig. 2

Plan View of Possible Neutrino and Hadron Front End Arrangement.